Claims

What is claimed is:

1. A method for calibrating an electromagnetic logging tool having a plurality of antennas disposed thereon with at least one antenna having its axis at an angle with respect to the axis of the tool, each antenna adapted to transmit and/or receive electromagnetic energy, comprising:
   (a) disposing a test loop about the electromagnetic logging tool such that the axis of the tool and a plane on which the test loop lies form a tilt angle that is between about 0 and 90 degrees;
   (b) measuring a signal induced in one of said antennas when another of said antennas is energized, the induced signal being affected by the test loop; and
   (c) determining a correction for the induced signal.

2. The method of claim 1, wherein step (c) includes applying to the induced signal a correction selected from the group consisting of a sonde error correction and temperature correction.

3. The method of claim 1, wherein step (c) includes taking another signal measurement at the antenna measured in step (b) without any effect associated with the test loop.

4. The method of claim 3, wherein taking another signal measurement comprises removing the test loop or opening a conductive loop on the test loop.

5. The method of claim 1, further comprising:
   altering a position of the test loop about the electromagnetic logging tool and repeating steps (b) to (c).

6. The method of claim 1, further comprising deriving calibration coefficients for at least one of the antennas.

7. The method of claim 1, wherein the tilt angle is 45 degrees.

8. The method of claim 1, wherein at least one of the antennas comprises a plurality of coils having mutually orthogonal axes.

9. The method of claim 1, wherein at least one of the antennas comprises a plurality of coils having non-parallel axes.

10. The method of claim 1, wherein the at least one antenna having its axis at an angle comprises a transverse antenna.

11. The method of claim 1, step (c) further comprising producing a corrected signal and comparing the corrected signal with a calculated signal.

12. The method of claim 11, further comprising deriving a gain or phase factor by comparing the corrected signal with the calculated signal.

13. The method of claim 11, further comprising multiplying the corrected signal by gain or phase factors.

14. The method of claim 11, wherein the calculated signal is based on a model including the electromagnetic logging tool and the test loop.

15. The method of claim 11, wherein step (c) includes determining a maximum or minimum value associated with the measured signal.

16. The method of claim 1, wherein step (b) includes rotating the test loop about the axis of the tool.

17. The method of claim 1, wherein step (b) includes displacing the test loop off the axis of the tool.

18. A system for calibrating an electromagnetic logging tool, comprising;

a plurality of antennas disposed on the logging tool with at least one antenna having its axis at an angle with respect to the axis of the tool, each antenna adapted to transmit and/or receive electromagnetic energy;

a test loop adapted for disposal about the logging tool such that the axis of the tool and a plane on which the test loop lies form a tilt angle that is between about 0 and 90 degrees; and

a processor adapted to calculate a correction for a signal induced in one of said antennas by another of said antennas, the induced signal being affected by the test loop.

19. The system of claim 18, wherein the tilt angle is 45 degrees.

20. The system of claim 18, wherein at least one of the antennas comprises a plurality of coils having mutually orthogonal axes.

21. The system of claim 18, wherein at least one of the antennas comprises a plurality of coils having non-parallel axes.

22. The system of claim 18, wherein the at least one antenna having its axis at an angle comprises a transverse antenna.

23. The system of claim 18, wherein the processor is adapted to apply to the induced signal a correction selected from the group consisting of a sonde error correction and temperature correction.

24. The system of claim 18, wherein the processor is adapted to calculate said signal correction using a signal induced at said antenna without any effect associated with the test loop.

25. The system of claim 18, wherein the test loop comprises a conductive loop adapted for selective opening or closing of said loop.

26. The system of claim 18, wherein the processor is adapted to produce a corrected signal and to compare the corrected signal with a calculated signal.

27. The system of claim 26, wherein the processor is adapted to derive a gain or phase factor by comparing the corrected signal with the calculated signal.

28. The system of claim 26, wherein the processor is adapted to multiply the corrected signal by gain or phase factors.

29. The system of claim 26, wherein the calculated signal is based on a model including the electromagnetic logging tool and the test loop.

30. The system of claim 18, wherein the processor is adapted to derive calibration coefficients for at least one of the antennas.

31. The system of claim 18, wherein the calculation for the induced signal correction includes determining a maximum or minimum value associated with the induced signal.

32. The system of claim 18, wherein the test loop is adapted for rotation about the axis of the tool.

33. The system of claim 18, wherein the test loop is adapted for displacement off the axis of the tool.

34. A system for calibrating an electromagnetic logging tool having a plurality of antennas disposed thereon with at least one antenna having its axis at an angle with respect to the axis of the tool, each antenna adapted to transmit and/or receive electromagnetic energy, comprising:

a test loop adapted for disposal about the logging tool such that the axis of the tool and a plane on which the test loop lies form a tilt angle that is between about 0 and 90 degrees;

a computer adapted to connect to the electromagnetic logging tool, wherein the computer is adapted to process a program with instructions to perform:

energizing a first antenna on the tool in the presence of the test loop;

measuring an induced signal at a second antenna on the tool; and

determining a correction for the induced signal.

35. The system of claim 34, wherein at least one of the antennas comprises a plurality of coils having mutually orthogonal axes.

36. The system of claim 34, wherein at least one of the antennas comprises a plurality of coils having non-parallel axes.

37. The system of claim 34, wherein determining the correction for the induced signal includes using a signal induced at the second antenna and not affected by the test loop.

38. The system of claim 34, wherein the test loop comprises a conductive loop adapted for selective opening or closing of said loop.

39. The system of claim 34, wherein determining the correction for the induced signal includes using a signal induced at the second antenna with the conductive loop opened.

40. The system of claim 34, the program including further instructions to determine a corrected signal and to compare the corrected signal with a calculated signal.

41. The system of claim 34, wherein determining the correction for the induced signal includes determining a maximum or minimum value associated with the induced signal.

42. The system of claim 34, wherein the test loop is adapted for rotation about the axis of the tool.

43. The system of claim 34, wherein the test loop is adapted for displacement off the axis of the tool.